ANNUAL REPORT ON THE STATE OF THE OCEAN AND THE OCEAN OBSERVING SYSTEM FOR CLIMATE

Executive Summary

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This Annual Report is a compilation of articles, progress reports, and references focused on the current state of the ocean and the status of the ocean observing system for climate in fiscal year (FY) 2003. The report synthesizes *in situ* observations integrated with models and scientific expertise to provide products to decision makers, the science community, and the public. This reporting framework establishes a formal mechanism for implementing a "user-driven" observing system and for reporting on the system's performance in meeting the requirements of operational forecast centers (e.g., National Centers for Environmental Prediction (NCEP)), international research programs (e.g., International Climate Variability and Predictability (CLIVAR) program), and major scientific assessments (e.g., Intergovernmental Panel for Climate Change (IPCC) report). Stakeholders are invited and encouraged to provide formal recommendations for system improvement and evolution as part of the annual report process.

Chapter 1 provides an introductory overview of the ocean and its role in climate with an explanation of the ocean's physical parameters that contribute to the hydrological cycle. Ocean-atmosphere interactions are addressed along with the impacts of climate change on sea ice extent and resultant sea level. Connections are made between ocean observations and economic and societal impacts.

Chapter 2 includes a series of summaries focused on ocean climate (anomalies) from FY 2003 placed in historical context, reasons why it is increasingly important to monitor climate variables, accompanying climate applications, and how the observing system needs to be enhanced to improve ocean analysis and product development. Chapter 2 focuses on the products linked with the observing system, specifically sea level, ocean carbon, sea surface temperature, surface currents, sea surface pressure, air-sea exchanges of heat, momentum, and freshwater, and heat content variations.

Chapter 3 focuses on the observing system and provides a compilation of all FY 2003 progress reports written by the OCO-funded project managers. These projects are focused on the mission of the Office of Climate Observation, namely, documenting long-term trends in sea level change, ocean carbon sources and sinks, ocean's storage and global transport of heat and fresh water, and the ocean-atmosphere exchange of heat and fresh water, along with accompanying parameters.

Chapter 4 contains selected abstracts from refereed publications, and a bibliography of science articles and publications published by the scientific community during FY 2003 treating the global observation of ocean heat, carbon, fresh water, and sea level change.

The driving force for this report is the Climate Change Science Program (CCSP) overarching question for guiding climate observations and monitoring - "What is the current state of the climate, how does it compare with the past, and how can observations be improved to better initialize and validate models for prediction or long term projections?"

Present ocean observations are not adequate to deliver the products described in Chapter 2 with confidence. The fundamental deficiency is lack of global coverage by the *in situ* networks. Present international efforts comprise approximately 45% of what is needed in the ice-free oceans and 11% in the Arctic. The *Second Report on the Adequacy of the Global Observing System for Climate in Support of the UNFCCC* concludes that "the ocean networks lack global coverage and commitment to sustained operations….Without urgent action to address these findings, the Parties will lack the information necessary to effectively plan for and manage their response to climate change." The *Strategic Plan for the U.S. Climate Change Science Program* calls for "complete global coverage of the oceans with moored, drifting, and ship-based networks" (Johnson, Chapter 3 of this report).

The critical nature of our understanding of the ocean's role in climate variability and change provides immediate justification for the presence of a global observing system, however, many other applications, including societal and environmental, validate the presence of an ocean observing system for climate.

Incremental advancements across all observing system networks occurred in FY 2003, enabling expansion from 40% completion in FY 2002 to 45% in FY 2003. In addition to the scientific activities completed by the principal investigators in FY 2003 (as outlined in Chapter 3), their accomplishments in the service arena are equally astounding. Principal investigators and project leaders served the scientific community through more than 70 appointments to science and implementation panels, science teams, advisory boards, as committee members, officers, and steering committee members. PIs presented at or attended 140 conferences and workshops. On more than a dozen occasions scientists contributed their time and talent through outreach during press/media interviews, public lectures, and school visits.

An Observing System Monitoring Center (OSMC) is in progress as a joint effort between the Pacific Marine Environmental Laboratory (PMEL), the National Data Buoy Center (NDBC), and NOAA's Office of Climate Observation (OCO). The OSMC system is an information gathering, decision support, and reporting system for the OCO to display the current and historical status of globally distributed data collection systems. The OSMC will eventually provide the data visualization tools necessary to identify the coverage of any collection of ocean platforms and parameters accessed with the use of any conventional web browser on the Internet and through a monitoring center and briefing area at the new OCO office in Silver Spring, Maryland.

International and interagency partnerships are central to the Climate Observation Program implementation strategy. All of the Program's contributions to global observation are managed in cooperation internationally with the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM), and nationally with the U.S. Integrated Ocean Observing System (IOOS). NSF has initiated their Ocean Observatories Initiative (OOI), which will potentially provide significant infrastructure in support of ocean climate observation, beginning in FY 2006. Commencement of an ongoing NSF-NOAA cooperative project for CLIVAR-carbon ocean surveys has proved to be an interagency-international-interdisciplinary success. ONR maintains a GODAE data server at Monterey that needs to be sustained after the experiment period (2003-2005) as permanent international infrastructure. NOAA ships and the UNOLS fleet provide ship support for ocean operations and NASA's development of remote sensing techniques is vital (Johnson, Chapter 3 of this report). The OAR laboratories, joint institutes and university partners are presently implementing most NOAA contributions to the global system.

With new and continuing partnerships the complete global ocean observing system for climate will become a reality.